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before midnight on April 30th. It is still in *Sagittarius* north of the "milk-dipper."

Neptune is in *Gemini,* a few degrees east of *Jupiter.*

THE CAUSE OF EARTHQUAKES AND MOUNTAIN FORMATION.[1]

By T. J. J. See.

Soon after the great earthquake of April 18th, the writer entered upon a general examination of the cause of earthquakes, because the explanations put forth to account for that phenomenon seemed inadequate. The conclusions finally reached have been embodied in a memoir just published in the *Proceedings* of the American Philosophical Society at Philadelphia: they had also been given in a public address at Leland Stanford Jr. University, on November 15th. The principal results are the following:—

(1) Volcanic activity, earthquakes, mountain formation, the feeble attraction of mountains noted in geodesy, the formation of plateaus and islands, and the great sea-waves which frequently accompany violent earthquakes, are all due to one common cause,—namely, the development of steam within or just beneath the Earth's crust, chiefly by the secular leakage of the ocean-bottoms, which are subjected to fluid pressure of nearly one thousand atmospheres by the superincumbent depth of water.

(2) As the development of steam is general under the seas, the strain under the Earth's crust would find relief chiefly around the margins of the oceans. The Pacific Ocean not only has high mountains all around it, but the land is rising geologically, and seven eighths of the active volcanoes of the world surround this great ocean. No active volcano is over about one hundred miles from the ocean or other large body of water, while many are submarine, and volcanic islands are forming all the time. Of the vapors emitted by volcanoes 999 in 1000 parts is steam, which again confirms the dependence

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[1] Abstract of a lecture delivered before the A. S. P. in Hearst Hall, University of California, November 24, 1906.

on the sea inferred from the remarkable geographical distribution of these vents.

(3) Heretofore the mountains have been explained by the contraction and secular cooling of the Earth; but the explanation is very inadequate. Rev. O. FISHER has shown that the actual mountains are about one hundred times higher than this theory will account for, and this discrepancy can only indicate the unsoundness of the theory. In his paper on the rigidity of the heavenly bodies (*A. N.* 4104) the writer has shown that no currents circulate within the Earth, either now or at any time since the formation of the crust; the cooling has therefore been confined to the crust, and the secular shrinkage has been wholly insensible throughout all geological time. The mountains therefore have been formed by the sea, and not by the secular cooling of the Earth. This explains why the mountain chains are generally parallel to the seashore.

(4) Mountains, plateaus, and islands have all been upheaved by the injection of steam-saturated lava, which dries and becomes pumice, some of which is blown out of those mountains which become volcanoes. The mountains are underlaid with pumice, and hence their feeble attraction noticed in geodesy. Earthquakes are more general than volcanoes, which break out where the elevation of the land opens an outlet through the crust; as a rule, the volcanoes are near the centers of the earthquake belts, and always near the sea. In most world-shaking earthquakes lava is pushed under the land, from beneath the sea; hence the terrible shaking which is so destructive to life and property. In South America the land along the seacoast is frequently upraised; and a seismic sea-wave follows.

(5) The seismic sea-wave is due to the sinking of the sea-bottom, after its support has been weakened by the expulsion of lava under the adjacent coast. Hence after the earthquake the water drains away to fill up the depression, the currents meet in the center and raise a ridge, and when this collapses the great wave returns to the shore to add to the horrors of the earthquake. The Andes are pushed up along the coast, while the adjacent sea-bottom is sunk down into a trough. If the earthquake uplifts the coast, and thus forms mountains along the seashore, while the wave is due to the collapse of the sea-bottom, it is clear that the coast is being packed underneath

with lava, while the bed of the sea is being undermined by the expulsion of material to raise the mountains.

(6) During the great earthquake in Alaska, September 3-20, 1899, which has been most carefully investigated by Professor R. S. TARR and LAWRENCE MARTIN,[1] the uplift of the land at the maximum amounted to 47⅓ feet, while elevations of seven to twenty feet were common, though slight depressions also occurred in a few places. Professor H. D. CURTIS, of the D. O. Mills expedition of the Lick Observatory, reports from Santiago[2] that the harbor at Valparaiso was found to be ten feet shallower after the earthquake of August 16th. These observations give the key to the problem of earthquakes and mountain formation. The indications of nature are plain enough, if we will only follow her teachings and examine the evidence on its merits. The first duty of the investigator is to study for himself; important truth is not discovered without impartial judgment, labor, and thought.

The reader is referred to the paper in the *Proceedings* of the American Philosophical Society for further details of the complicated processes arising in earthquakes, mountain formation, and kindred phenomena.

NAVAL OBSERVATORY, MARE ISLAND, CAL.,
February 1, 1907.

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[1] *Bulletin of the Geological Society of America,* May, 1906.

[2] Cf. *Argonaut* of November 2, 1906.